Supporting Industries
Industry of the Future

Fiscal Year 2004 Annual Report

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry
through improvements in energy and environmental performance

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Industrial Technologies Program — Boosting the Productivity and Competitiveness of U.S. Industry

Industry consumes 33 percent of all energy used in the United States. By developing and adopting more energy efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. EERE's Industrial Technologies Program (ITP) is working to build the Industries of the Future through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices to reduce energy intensity in the industrial sector. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. The primary long-term strategy is to invest in high-risk, high-return R&D. Investments are focused on technologies and practices that provide clear public benefit but for which market barriers prevent adequate private sector investment.

ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 55 percent of industrial energy consumption.

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Steel

ITP uses a leveraging strategy that maximizes the energy and environmental benefits of its process-specific technology investments by coordinating and cooperating with energy-intensive industries. By working closely with the private sector, the ITP is able to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. The ITP public-private partnerships also facilitate voluntary efforts, such as the President's Climate VISION initiative, to encourage industry and government to reduce greenhouse gas emissions.

ITP also conducts R&D projects on enabling technologies that are common to many industrial processes such as industrial energy systems, combustion, materials, and sensors and process control systems. In addition, ITP funds technical assistance activities to stimulate near-term adoption of best energy-saving technologies and practices within industry. These activities include plant assessments, tool development and training, information dissemination, and showcase demonstrations.

New technologies that use energy efficiently also lower emissions and improve productivity. By leveraging technical and financial resources of industry and government, the ITP partnerships have generated significant energy and environmental improvements that benefit the nation and America's businesses. Energy-intensive industries face enormous competitive pressures that make it difficult to make the necessary R&D investments in technology to ensure future efficiency gains. Without a sustained commitment by the private and public sectors to invest in new technology R&D and deployment, the ability to close the gap between U.S. energy supply and demand will be severely compromised.

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EXECUTIVE SUMMARY

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) Supporting Industries (SI) portfolio fosters high-risk, high-payoff R&D to develop advanced technologies that will decrease energy intensity and reduce waste generation in selected supporting industries and the related Industries of the Future. The main aim is to improve energy and environmental performance of the manufacturing processes while simultaneously reducing the product costs. The portfolio addresses seven industries: industrial-heating equipment, heat treating, forging, welding, powder metallurgy and particulate materials (PM2), advanced ceramics, and carbon products. All these industries are integrally linked to end-use industries and are significant energy consumers using more than 5.94 quads per year in the U.S. In addition, a program support study titled "Profile of Total Energy Use for the U.S. Industry" identified other industries that can be categorized as supporting industries. These include fabricated metals, construction, computer electronics, and oil and gas exploration which are also large energy consumers, using approximately 5.13 quads per year in the U.S.

Manufacturing and fabricating processes are the main causes of high energy consumption in all of these supporting industries. Only a small fraction of this energy consumption is attributed to off-site and fuel transport losses or use of residual, distillate, LPG/NGL, and other fuels.

The supporting industries directly affect the essential functions that other U.S. industries must perform. They also add value to the intermediate products of these industries to prepare them for the end-use markets. the **Industrial-heating equipment industry** provides process heating equipment to manufacturers that are used for fluid heating, calcining, drying, heat treating, material heating, melting, smelting, curing, and forming processes. **Forging and heat treating industries** improve the product quality and strength of the intermediate products by controlling microstructure, chemical composition, and physical properties of the materials they are made of. The **welding industry** not only offers processes to assemble and fabricate products, but it is also engaged in the development of weldable alloys and new technologies to join dissimilar metals, ceramics, polymers, and engineered materials. The **Powder metals industry** provides cost-effective alternatives to machining, forging, and casting, to produce simple, complex, and difficult to make near-net shape parts and components by using recycled metals and non-metallic and combination materials. It is also creating developmental and crucial materials for U.S. industries. **Carbon products industry** utilizes by-products from the other primary operations (e.g., coal, tars, petroleum and cokes from the chemical and petroleum industries) to produce many end-use products, and critical materials and components for U.S. industries such as anodes for aluminum production, electrodes for steel mini-mills, as well as side walls and carbon black for steel-making furnaces. The **Advanced ceramics industry** develops technologies for making high-performance (heat/corrosion/erosion/fatigue-resistant), low-maintenance, high-efficiency materials and coatings for a variety of applications to IOFs.

A Successful Strategy with Industry

DOE's Office of Energy Efficiency and Renewable Energy leads federal development of advanced energy-efficient and environmentally-friendly industrial technologies. Supporting Industries R&D is a component of the overall EERE strategy, contributing to a reduction in energy intensity of industry, a goal outlined in the National Energy Policy.

EERE/ITP is working to build the Industries of the Future through a strategy that is based on multi-year planning, industry involvement and input during the planning process, and careful analysis and data-based decision making. This strategy not only takes into consideration the interests of the industry as described in their R&D Technology Roadmaps, but also consists of an agenda of analytical studies that provide the basis for decision-making. For instance, the Supporting Industries portfolio has published seven technology roadmaps that provided the basis for focusing R&D by identifying industry research interests. The *Supporting Industries Energy and Environmental Profile*, *Profile of Total Energy Use for the U.S. Industries*, *Furnace Demographic Study*, *Research Priorities for the Supporting Industries*, the footprint analyses and bandwidth analysis for the supporting industries study were developed using both government and industry data and information, and industry expertise to provide the next level of prioritization for the portfolio. By using these studies, the portfolio is able to design a multi-year R&D plan based on the focus area, barrier,

and pathway approach. In this approach, a limited number of critical technology focus areas are identified along with the technical barriers preventing their successful implementation. A multi-year plan (called a "Pathway") is then developed that will guide the R&D activities leading to a successful development of the focus area technology. The "Pathways" are then the basis for solicitations of pre-competitive R&D that addresses, both energy efficiency goals outlined in the National Energy Policy and the five supporting industries research priorities. This successful strategy has now evolved to a point where it provides focus on potentially high-impact research to make revolutionary improvements in ironmaking and steelmaking.

To maximize limited financial resources, ITP's SI portfolio research needs are integrating with the other ITP portfolios. SI is also developing cost-shared projects and inter-industry partnerships, as well as allied partnerships to deploy ITP best-practice energy management tools and emerging technologies.

Corporate peer reviews and annual portfolio reviews assess the SI portfolio performance and provide it the industry feedback it needs. There are nine ongoing projects that seek to fulfill the technology roadmap research needs of the forging, heat treating, welding and powder metals industries. These projects have a total estimated energy-savings potential of about 13.6 trillion Btu per year in the U.S. These projects are providing crosscutting research for the other IOFs by developing advanced high-efficiency technologies, design tools, process-material optimization methodologies, and model-based controls. They will improve process efficiencies by taking measures such as reducing cycle times and scrap, improving product quality and strength of the intermediate products, and creating the ability to join dissimilar metals.

FY 2004 Highlights

Komtek, Inc., Forging Industries Association (FIA), Oak Ridge National Laboratory (ORNL) and Northeastern University developed a super energy-efficient furnace (SEEF) in which a hybrid infrared system enables rapid heating, preventing grain growth in billets, resulting in improved microstructure and mechanical properties. SEEF drastically reduces billet preheating time from six hours to 18 minutes. Over 2,000 billets of aluminum, each weighing 1.3 kg, were processed at Queen City Forging Company using this furnace system. The technology is applicable to billet preheating, heat treating forged parts, annealing and normalizing, stress relieving, and preheating and post-annealing welds. SEEF's overall efficiency is 30 percent, as compared to conventional furnace efficiency of about 10 percent, translating to an estimated national energy savings of up to 0.8 trillion Btu per year for aluminum forgings, plus similar savings for copper, brass, and titanium for a total of about 1.6 trillion Btu per year. This project is an *R&D 100* Award winner for 2004.

The Worcester Polytechnic Institute (WPI) project, "Energy-Savings Model for the Heat Treatment of Castings," is developing an integrated system of software, databases, and design rules to predict and optimize thermal cycle time and create specified microstructures and desired properties. This project will help reduce energy consumption, while increasing casting quality.

Another WPI project, "Materials and Process Design for High-Temperature Carburizing Billets," will integrate process and materials optimization to enable widespread application of high-temperature carburization, resulting in reduced cycle times. Vacuum and plasma methods are being investigated to ensure broad availability of commercial heat treatment processes. Distortion-free, high-performance bearing and gear materials will be used in the transportation sector. The project will create a new class of thermallystable, ultra-durable, case-hardened tools and die steels, enabling major productivity gains in steel and aluminum forging and die casting. Because of this project, a new class of carburizing steels with broad applicability may quickly replace conventional steels. The U.S. annual energy consumption for carburizing will decrease from 80 trillion Btu to 20-24 trillion Btu. The use of the methods created will reduce greenhouse gas emissions and reduced scrap to result in energy savings. In addition, hard chromium plating would become unnecessary in several applications. The expected lifetime of a furnace using this new technology is approximately 20 years.

Lincoln Electric Co., ORNL, and Pennsylvania State University are close to developing a "Novel Optimization Methodology for Welding Processes" to describe weld pool, microstructure, and mechanical properties of steel welds as a function of process variables and alloy composition. The developments so far include: (a) heat transfer model to calculate weld pool characteristics for gas metal arc welding (GMAW); (b) microstructure model to predict solidification and solid state transformations in steel welds; and (c) generic optimization methodology used to optimize weld strength. This technology will lead to the rapid deployment of

advanced materials for steel, chemicals, and other industries. This project will reduce wasted energy caused by expensive trial-and-error experimentation used for optimization and will maximize fabricated structure yield.

The Ohio State University (OSU) project, "Innovative Die Materials and Lubrication Strategies for Clean and Energy Conserving Forging Technology," is developing and implementing innovative die materials and surface coating strategies such as composite dies and self-lubricating coatings that will reduce energy consumption and costs and improve forged parts' quality. OSU developed a fully-equipped forging cell, the first of its kind in the United States. Project partners will use this cell to research industrial-sized equipment. This project's benefits include: eight times increase of current die life; 90 percent reduction in energy input and a 50 percent reduction in costs; 90 percent reduction in particulate emissions from lubricants; 90 percent decrease in die-related uptime and 50 percent decrease in downtime; creation of wear and failure data to devise preventive maintenance and repair schedules; and targeted limit of 25 parts per million rejection rate.

INDUSTRY OVERVIEW

Supporting Industries Overview

Several diverse industries play a key role in improving the DOE-ITP's nine Industry portfolios. These industries perform vital roles in supporting these industries, providing materials and processes necessary to the products that these industries create. They also provide these industries with recommendations to help reduce energy consumption. The seven supporting industries currently addressed by the SI subprogram are:

- Industrial-Heating Equipment
- Heat Treating
- Forging
- Welding
- Powder Metallurgy and Particulate Materials
- Advanced Ceramics
- Carbon Products

Supporting industries supply materials and processes necessary to form and fabricate the products before they are marketed to end-use industries. The powder metals industry uses faster, more cost-effective manufacturing processes to produce products, parts, and components for specific applications.

Supporting Industries Shipments and Market Share

The economic data published for SI includes process heating, heat-treating, welding, advanced ceramics, forging, powder metallurgy, and carbon products. The SI industries, except for process heating, employ approximately 105 thousand people and have a value of shipments that totals $48.6 billion. Below is an overview of each of the SI markets. Exhibit 1 (page 2) illustrates each industry's annual shipments, as well as estimated employees.

Industrial-Heating Equipment – With its wide and varied industrial applications, industrial-heating equipment directly and indirectly affects more than 300,000 establishments in the United States.

Heat Treating – The heat-treating industry is directly related to metal producing and secondary processing industries, accounting for $20 billion in the United States annually and $75 billion worldwide. In the United States, approximately 5,000 facilities operate roughly 55,000 furnaces, 66 percent of which are gas-fired and the remainder of which are electrically heated.

Forging – The forging industry's total output in North America is estimated to exceed $6 billion annually. This industry employs approximately 36,000 workers, the majority of whom are employed by processing iron and steel facilities. Forging consumes approximately 1.67 billion kWh of electricity each year, a relatively low amount compared to other technologies producing finished or semi-finished parts. This industry is projected to increase shipments by 9.1 percent in 2004.

Welding – Welding expenditures contribute substantially to the U.S. economy. Many industries that employ welding processes provide the backbone for our national defense, infrastructure, and economic security. Revenue from these industries totaled over $3.1 trillion in 2000, roughly one-third of the total U.S. Gross Domestic Product (GDP). Energy consumption for this industry is estimated at approximately 129 trillion Btu annually, demonstrating welding's widespread manufacturing applications.

Advanced Ceramics – The United States currently accounts for $8.5 billion, or 35 percent of the global advanced ceramics market. Forecasts project a global market growth of 8 percent per year between 2000 and 2005, totaling $11.7 billion. In the first six months of FY 2003, advanced ceramics accounted for over $490 million in shipments. During the same time period in FY 2004, shipments accounted for over $504 million. Shipments are on track for a 3 percent increase in FY 2004.

Powder Metallurgy and Particulate Materials (PM2) – U.S. demand for metal powders is estimated to increase by about 5 percent annually, equal to over $2 billion in increases by 2008. Because many new engines contain powder forged rods and bearing caps, metal powder distribution in the automotive industry has significantly increased. By volume, the demand side is expected to grow more than 3 percent annually to about 690,000 tons by 2008. The PM2 industries consume 16 trillion Btu each year.

Carbon Products – A large portion of the carbon products industry is built upon recovering and processing by-products from other primary operations. The demand for activated carbon in the U.S. is projected to increase by almost 3 percent, or 450 million pounds, each year until 2006. Market value is also expected to rise by about 3 percent, or $332 million each year.

Exhibit 1
Economic Data for the Currently Addressed Supporting Industries

Supporting Industry	Value of Shipments ($billion)	Number of Employees
Heat Treating	$20.0	ND
Forging	$6.0	36,000
Welding	$4.0	18,300
PM2	$7.3	40,000
Advanced Ceramics	$8.5	ND
Carbon Products	$2.8	11,000
TOTAL	**$48.6**	**105,300**

ND: No data available
Compiled by Supporting Industries Energy and Environmental Profile

THE CHALLENGE

The SI portfolio encourages collaborative research efforts to leverage its limited resources. The portfolio seeks to accomplish this by integrating SI research needs with other ITP portfolios and cross-cutting research portfolios. In order to encourage coordinated and joint solicitations and multiple-industry research proposals, the portfolio conducts analytical studies and implements results, establishes allied partnerships with trade and professional associations, and encourages partnerships between ITP and other federal agencies to leverage SI technology roadmap research. With the aid of these partnerships, the portfolio aims to create more diverse industrial and consumer products, novel materials applicable to other ITP portfolios and research to solve common dilemmas.

Some innovative concepts sponsored by the subprogram are under development by smaller entrepreneurs. The portfolio will explore methods and services that will help to successfully commercialize these technologies. The program maintains communication with the industry on project results, emerging technologies, best practices and other successes involving SI-sponsored technologies. SI projects focus on potentially rewarding technologies that appear too risky or expensive for the private sector to develop independently.

Energy Use in Supporting Industries

Supporting industries account for a significant amount of energy consumption within the chain of raw materials, forming and finishing, and end-use industrial sectors. The energy-savings potential is enormous; for the seven supporting industries in the current SI portfolio, the total estimated energy consumption is 5.94 quadrillion Btu per year for the currently addressed supporting industries.

Industrial-heating equipment technologies supply heat to nearly all manufacturing processes, including basic materials and commodities such as steel, cement, and composites, and value-added products such as electronics, computer chips and textiles. These heating processes consume about 5.2 quadrillion Btu of energy annually, accounting for nearly 17 percent of all industrial energy use.

Heat-treating processes consume about 458 trillion Btu per year. These processes are essential to building automobiles, aircrafts, spacecrafts, computers and other heavy equipment. Heat treating is closely linked to manufacturing products and parts made of steel, alloys of aluminum, copper, magnesium, nickel and titanium. The vast majority of heat-treated materials are iron and steel with parts that are cast, forged, welded, machined, rolled, stamped, drawn, and extruded. Other heat-treated materials are brass, bronze and titanium alloy structures.

Welding processes are divided in two main classes: fusion welding for similar or same family materials, and solid state welding for similar and dissimilar materials. Welding processes apply to practically all manufacturing and construction industries including heavy, aerospace, petroleum and automotive. The total energy consumption of the U.S. welding industry is about 129 trillion Btu per year (54 for heavy industry, 43 for light industry, and 32 for automobile, aircraft and aerospace industries).

Forging components are used in over 20 percent of the products that comprise U.S. GDP. Some of these applications include automotive and truck, aerospace, off-highway equipment/railroads, general industrial equipment, shipbuilding, and agricultural equipment. Forging is a key aspect of the metal manufacturing process. Energy consumption of the forging industry ranges between 9-18 trillion Btu per year. When system inefficiencies and energy consumed in other areas of a forge shop are included, the forging energy consumption can be 6,000 – 8,000 Btu per pound; based on forging shipments, energy consumption amounts to 28 - 37 trillion Btu per year in the U.S. forging industry.

The PM2 industry produces near net-shape components with tight dimensional tolerances at moderate temperatures with minimized finishing operations, cost and energy use. PM2 components are used in many markets, including metal cutting, automotive, tools, motors and controls, aircraft and turbine engines, oil/gas well drilling equipment, tractors, etc. Powder manufacturing and sintering are the most energy-intensive steps in the process, consuming an estimated 36.3 million Btu per ton of parts. According to FY 2000

statistics: a 401,000 tons yield, the total estimated energy consumption of the PM2 industry is about 16 trillion Btu, annually.

The carbon products industry consumes about 0.25 quad of energy per year in U.S. production. It supplies critical materials and components to essential U.S. industries including aluminum, steel, chemicals, aerospace, and environment. The industry consumes about 107 trillion Btu of energy per year. Some carbon products include Hall-Heroult anodes, cathodes, and sidewalls for aluminum manufacturing, electrodes, and carbon blocks for steel furnaces, crucibles, heaters, and filters.

Exhibit 2
Energy Consumption of Currently Addressed Supporting Industries

Supporting Industry	Energy Use (TBtu)	Operation	Application Industry	Energy Saving Opportunities
Heat Treating	458	Softening, strengthening, surface hardening and heat/ wear/corrosion resistance, improved ductility	Ferrous and non-ferrous metals and alloys, structures	- Integrated process models - Real-time sensors & controls - Hybrid heating systems
Welding	129	Fusion welding, solid-state welding, brazing and soldering	Heavy & light manufacturing, 9 ITP industry portfolios, automotive, construction	- Less pre- & post-heating - Reduced over welding
Forging	28-37	Cold/warm/hot forging, heat treating	Automotive, agriculture, railroad, tools, valves, 9 ITP industry portfolios, aerospace	- Use of induction heating - Imp monitoring & control
Powder Metallurgy	16	Powder production (atomization, chemical treatment, electrolysis), press & sinter, powder injection molding/forging	Automotive, consumer goods, cereals, paints, pyrotechnic/explosives	- More efficient powder manufacture & sintering
Advanced Ceramics	No data	Material milling, greening (slip cast, inject/sol gel molding, extrusion) drying, sintering, finishing (electrical furnaces)	Automotive, tools, dies, rotors, wear pads, pumps, liners, capstans, chemical industry	- Automation; adv fabrication - Application of adv ceramics
Carbon Products	107	Coal tars, petroleum cokes, process to pitches & cokes, precursors to plastics, carbon & graphic products	Steel electrodes, aluminum anodes, carbon black, specialty graphite, C-C materials	- Continuous processing - Low-temp processing
TOTAL	**742**			

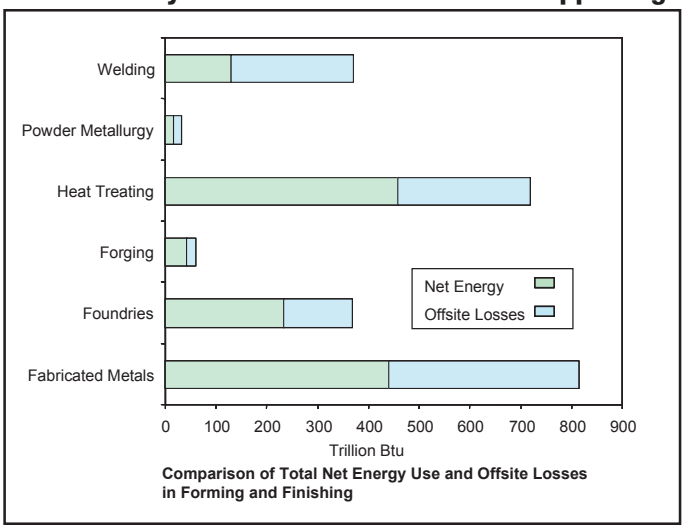
Key Pathways

The ITP's planning strategy is to: (1) leverage resources with the other ITP/EERE subprograms; (2) use industry input, e.g., technology visions and roadmaps; conduct analytical studies and hold industry workshops/ meetings to identify Grand Challenge concepts; (3) continue technology development; (4) solicit proposals based on opportunity analyses; (5) develop and demonstrate technologies; and (6) help deploy ITP BestPractices tools.

The RAND ITP-Database Navigator (DBN) was developed to integrate the material research needs of all ITP's portfolios and supporting industries, providing the navigational capability to determine multiple-industry energy-saving research opportunities. The DBN is posted on the SI Web site so that industry can develop multiple-application research proposals. ITP can also use DBN to develop joint or coordinated solicitations, investigate multiple-industry research areas for further analysis, and identify technology options to solicit "Grand Challenge" projects.

The research for the Advanced Ceramics and Carbon Products industries are pursued under other DOE programs. The pathways used for the other ITP-sponsored supporting industries are as follows:

Exhibit 3
Energy Use in Currently-Addressed and Additional Supporting Industries



Comparison of Total Net Energy Use and Offsite Losses in Forming and Finishing

Industrial-Heating Equipment: The Process Heating Steering Committee (PHSC) described under the "Partnership Section" of this report is working closely with the SI portfolio to define "Industrial Heating Equipment of the Future" Grand Challenge concepts. These concepts will be based on inputs from the IES-ES Roadmap, the Process Heating and Combustion Roadmaps, the Furnace Demographic Study and the "Industrial-Heating Equipment of the Future Conference."

Heat Treating: The heat treating projects that are currently active include: heat treatment of aluminum castings, carburizing, rapid preheating of aluminum billets, and intensive quenching. These projects are developing prediction software for thermal cycles; identifying microstructure, properties and material distortion; developing model-based controls to achieve desired mechanical properties; and setting standards for quenching forgings.

Forging: One active project involves developing innovative die materials, including ceramic composites and self-lubricating coatings, to substantially improve the die life.

Welding: Welding process optimization, solid-state metals joining, and fatigue-resistant welding projects are currently underway. These projects are addressing fundamental approaches based on science and neural networks; joining of dissimilar metals; and heat-input control for gas metal arc welding (GMAW).

Powder Metallurgy: One active project is developing continuous feedback control of lubricant/binders, which will be used to adjust sintering of the metallic components to make powder metal parts.

FY 2004 HIGHLIGHTS AND ACCOMPLISHMENTS

The SI portfolio received $700,000 in funding in FY 2004. The portfolio currently consists of nine active industry cost-shared projects that include academia and national laboratory partnerships.

Broad Industry Partnership

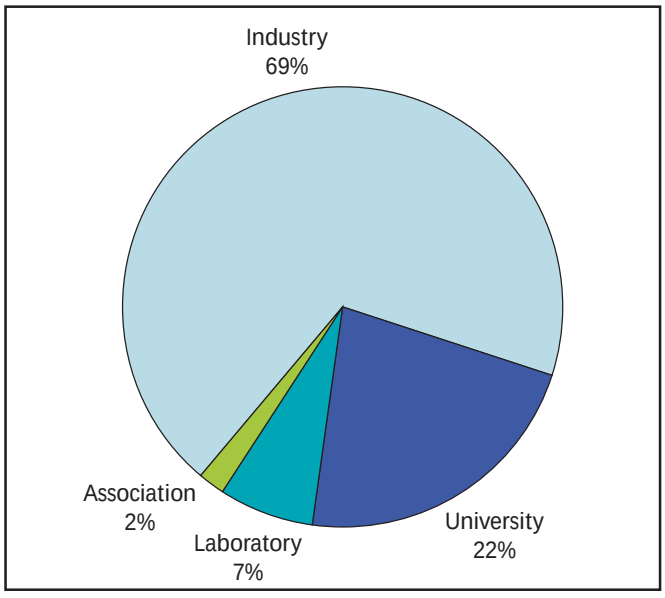
The SI portfolio touts a significant cost-shared participation by industry, trade and professional associations, universities, and national laboratories. Several supporting industries have begun to leverage their R&D resources by forming alliances and short-term partnerships with technical societies, trade and professional associations, and academia and government, through which they can pool their knowledge and specialized facilities. Summaries of these alliances and collaborations are provided in the Partnership Highlights section of this report. Currently, the portfolio has 45 project partners. Most of these partners are located in East Coast and Midwestern states, but a few are located in the West. Exhibit 4 lists the SI portfolio partners and their locations throughout the United States.

Exhibit 4
Research Performers and Project Partners of Supporting Industries

Advanced Joining Technologies	Euclid Heat Treating	Pacific Northwest National Lab.
Advanced Metal Products	Forging Industries Association	Pennsylvania State University
Air Products and Chemicals	General Motors Corporation	Pratt & Whitney
Akron Steel Treating	Houghton International	Queen City Forging Company
Aluminum Company of America	Industronics Service Company	Sandia National Laboratories
AMCAST Industrial Corporation	IPSEN International	S. Dakota School of Mines & Technology
Argonne National Laboratory	IQ Technologies, Inc.	Summit Heat Treating
Bodycote Thermal Processing	Kolene Corporation	Surface Combustion
Brigham Young University	KomTek	The Boeing Company
Case Western Reserve University	Lincoln Electric Company	Timken Company
Caterpillar, Inc.	Northeastern University	Torrington Company
Center for Heat Treating Excellence	Northwestern University	UES Software
Deere & Company	Oak Crest Institute of Science	University of Connecticut
Eclipse Combustion	Oak Ridge National Laboratory	University of Massachusetts-Amherst
Edison Materials Technology Center	Ohio State University	Worcester Polytechnic Institute

Exhibit 5 illustrates R&D funding by partner type, most of which are members of industry. SI supports several types of partners from industry, universities, laboratories, and associations.

Exhibit 5
Supporting Industries Partners by Sector



A Diverse Research Portfolio

The following are the nine active SI projects related to aluminum alloy forgings, aluminum castings, welding processes, die materials, heat treating, and powder metals sintering. Exhibit 6 (page 8) illustrates potential energy-savings for these projects.

Superior Joining and Energy-Efficient Manufacturing Through Friction Stir Welding, Advanced Joining Technologies: This project proposes to develop and deploy friction stir welding (FSW) as a superior method to join steels and aluminum alloys. The project has four main tasks: FSW process development, material characterization, predictive numerical simulation of FSW and industrial application deployment and validation. The estimated energy-saving potential for this project is 2.5 trillion Btu per year by 2020.

Development of Continuous, Direct-Feedback Control Systems for Sintering of Metallic Components, Worcester Polytechnic Institute: This project will focus on the development and field testing of a continuous, direct-feedback system for the control and optimization of the de-lubrication process during the sintering of powder metallurgy components. The estimated energy-saving potential is 1.3 trillion Btu per year by 2020.

Materials and Process Design for High-Temperature Carburizing Integrating and Performance, Worcester Polytechnic Institute: This project focuses on the development of a fast high-temperature carburizing process using a computational materials design approach developed by Northwestern University's Steel Research Group. The project will integrate optimization of process and materials to enable a broad usage of high-temperature carburization to reduce cycle times. Estimated energy-savings is 4.6 trillion Btu per year by 2020.

Innovative Die Material and Lubrication Strategies for Clean and Energy-Conserving Forging Technology, Ohio State University: This project will develop and implement innovative die material and surface coatings such as composite dies and self-lubricating coatings to increase die life. The project will also decrease process energy input by 15 percent, reduce energy cost per piece by 50 percent, reduce particulate emissions from lubricants by 90 percent and increase die-related up-time to 90 percent. Estimated energy-savings potential is 1.7 trillion Btu per year by 2020.

Fatigue Resistant, Energy Efficient (FREE) Welding, Caterpillar, Inc.: This project will focus on using pulsed waveforms to produce fatigue-resistant welds in high-strength steels, structural steels, and aluminum. Estimated energy-saving potential is 1.2 trillion Btu per year by 2020.

Intensive Quenching Technology for Heat Treating and Forging Industries, Edison Materials Technology Center (EMTEC): This project is focused on developing a method of uniformly quenching heated metal parts with a very high cooling rate that is several times greater than conventional quenching processes. Estimated energy-saving potential is 400 billion Btu per year by 2020.

An Energy-Savings Model for the Heat Treatment of Castings, Worcester Polytechnic Institute: This project will develop an integrated system of software, databases, and design rules to enable quantitative prediction and optimization of the heat treatment of castings to reduce energy consumption, increase quality and productivity, and reduce heat treatment cycle times. Estimated energy-savings potential is 1.0 trillion Btu/year in 2020.

Enhancement of Aluminum Alloy Forgings Through Rapid Preheating of Billets, KomTek, Inc.: This project has worked to develop a new hybrid infrared heating system, or super energy-efficient furnace (SEEF), that permits rapid and uniform heating of aluminum alloy billets prior to forging. Commercialized by Infrared Heating Technologies, this technology has been proven to significantly reduce heating time, decrease energy consumption, and improve metallurgical and mechanical properties in forging. The technology is applicable to billet preheating, heat treating forged parts, annealing, normalizing, stress relief and weld treatment. The energy efficiency of SEEF is 30 percent, compared to 10 percent for conventional processing. This improved energy efficiency means a 0.8 trillion Btu per year energy-savings for aluminum forgings, plus similar savings for copper, brass and titanium, for a total savings of 1.6 trillion Btu per year. Estimated energy-saving potential is 500 billion Btu per year by 2020.

Novel Optimization Methodology for Welding Process/Consumable Integration, The Lincoln Electric Company: This project team is developing a novel methodology which will describe weld pool characteristics, microstructure, and mechanical properties of steel welds as a function of process variables and alloy composition. Developments include a numerical heat and transfer model to calculate weld pool characteristics during gas metal arc welding (GMAW) of steel plates; a microstructure model based on thermodynamics and kinetics to predict solidification and solid-state transformations; and a generic optimization methodology to combine different constraints. This technology will lead to a rapid deployment of advanced materials destined for steel, chemical and other industries. In addition, these developments will reduce energy waste caused by expensive trial-and-error experimentation; achieve optimization; and maximize the yield of fabricated structures. Estimated annual energy-savings is 400 billion Btu by 2020.

Exhibit 6
Summary of Potential Annual Energy Savings from the Nine Active Projects

Name of SI Partner	Name of SI Project	Potential Energy Savings (2020)
Advanced Joining Technologies	Superior Joining and Energy Efficient Manufacturing Through Friction Stir-Welding	2.5 trillion Btu
Caterpillar, Inc.	Fatigue-Resistant, Energy-Efficient (FREE) Welding	1.2 trillion Btu
Edison Materials Technology Center (EMTEC)	Intensive Quenching Technology for Heat Treating and Forging Industries	0.4 trillion Btu
Worcester Polytechnic Institute (WPI)	Development of Continuous, Direct-Feedback Control Systems for Sintering of Metallic Components	1.3 trillion Btu
WPI	An Energy-Savings Model for the Heat Treatment of Casting	1.0 trillion Btu
WPI	Materials and Process Design for High-Temperature Carburizing Integrating and Performance	4.6 trillion Btu
Ohio State University	Innovative Die Material and Lubrication Strategies for Clean and Energy Conserving Forging Technology	1.7 trillion Btu
KomTek, Inc.	Enhancement of Aluminum Ally Forging Through Rapid Preheating of Billets	0.5 trillion Btu
The Lincoln Electric Company	Novel Optimization Methodology for Welding Process/Consumable Integration	0.4 trillion Btu
TOTAL		**13.6 trillion**

Partnership Highlights

U.S. manufacturing companies and their trade and professional associations are establishing partnerships and cooperative alliances with the government and academia. This strategy centers on the development of new and improved materials and products while partners strive to reach coincident goals and targets.

Partnership Efforts and Successes for Supporting Industries

ITP has created many leveraging opportunities for the supporting industries. Several supporting industries began to leverage their limited R&D resources by forming long-term alliances and short-term partnerships with technical societies, trade and professional associations, academia and government, through which they can share their knowledge and specialized facilities. A summary of each of these partnerships is below.

Allied Partners: Allied partnership is a key element of the ITP BestPractices area. Allied partners work to provide energy efficiency information, products, services, and support to industrial manufacturers. An Allied partner agreement represents a shared, voluntary commitment to promote industrial energy efficiency. Four allied partners who have signed on to work with SI include: Industrial Heating Equipment Association (IHEA), Forging Industries Association (FIA), Metal Powder Industries Federation (MPIF), and the Center for Heat Treating Excellence (CHTE).

Process Heating Steering Committee (PHSC): Established with the sponsorship of ITP, membership consists of IHEA member company executives, ITP industry executives (steel, aluminum, glass, forging, chemicals) and ITP representatives. Through teleconferences and periodic meetings, members provide input on their industry needs and concerns, possibilities of collaborative efforts, and steps to advance technologies for improving equipment (furnaces, process heaters, kilns, dryers etc.). Its subcommittees in materials, energy management tools, sensors and controls, and research and development are active in identifying high-impact Grand Challenge concepts and collaborating with national laboratories.

The Center for Heat Treating Excellence (CHTE): This alliance between the industrial sector and university researchers was established in 1999 at the Worcester Polytechnic Institute. Through a member-driven portfolio, it addresses short- and long-term needs of the heat treating industry by applying fundamental research to solve industrial problems and to advance heat treating technologies.

Materials Treating Institute (MTI): The heat treating, forging and welding industries collaborate with MTI and the ITP Chemical portfolio to develop unique and special purpose materials for the chemical industry.

Partnership Efforts by the Forging Industries Association (FIA): FIA, in coordination with ITP, leveraged research funds and generated more than $13 million for funding commercialized projects. FIA also formed several industry-university alliances, which led to various roadmap implementation projects. These alliances are outlined below:

1. Center of Excellence in Forging Technology (CEFT): As a spin-off of the SI advanced die materials project, CEFT was established as a university-industry collaboration involving automotive, steel, aluminum, metal casting and defense industries. Located at Ohio State University (OSU), CEFT works closely with CHTE.
2. Ohio Institute of Environmentally Efficient Manufacturing (OIEEM): The State of Ohio is co-sponsoring this CEFT initiative, which aims to explore manufacturing alternatives to less energy-efficient technologies. In addition, this initiative creates a collaborative research effort between federal agencies, state agencies, OEMs, and suppliers. Trade associations and national labs like WRL and NASA will play an integral role in the success of this initiative.
3. Forging Defense Manufacturing Consortium: This $15 million R&D project is demonstrating substantial improvements in the forging supply chain. This six-year project will produce multi-attribute dies for the forging and die-casting industries.
4. Joint Industry Alliance (JIA) - American Iron and Steel Institute's (AISI) Bar and Rod Group, FIA, and ASM Heat Treatment Society (HTS), formed the JIA with the ITP Steel portfolio's sponsorship and ORNL as their technical partner. This alliance seeks to carry out crosscutting, pre-competitive research to resolve industrial development issues, and to produce a database that could be used to compare product conditions before and after forging and heat treating operations. Its membership includes trade associations, suppliers, end-users, and federal government. The JIA is extending its efforts to the Center for Powder Metallurgy Technology, end-use industries, and the DOC-NIST program.
5. Forging Industry Association's (FIA) Plant Engineering Committee Meetings: Participants from 25 companies and six states represent commercial metal forgings producers and their suppliers, addressing specific plant operation issues.

Plant-Wide Assessments

Plant-Wide Assessments (PWA) investigate overall energy use in industrial facilities, which can account for 10 percent or more of an industry's total operating costs, and highlight opportunities for best energy management practices for industry, including the adoption of new, efficient technologies. BestPractices works with supporting industries to characterize findings and document savings that can be replicated in other facilities and industries for multiplied savings. Companies that participate in assessments can expect to realize a minimum of $1 million in savings annually from energy costs, waste reduction, and increased productivity, usually with a payback in less than 18 months. Plant-wide assessments have helped realize significant energy-saving potential.

Exhibit 7 displays six plant-wide assessments awarded to SI plants since FY 2000.

Ford Motor Company, Wayne, MI, awarded in November 2003 (SI): Ford Motor Company will work with Energy Information Systems (EIS) and E3M, Inc. to assess opportunities for reducing energy use, waste, and production costs. The project will focus on the truck plant's paint shop, characterizing the production process to identify energy-savings opportunities in the painting operation. Ford will provide $102,000 and DOE will contribute $100,000 for the assessment.

Exhibit 7
Plant-Wide Assessments Awarded to SI Plants Since FY 2000

Company Name and Plant Location	Date Awarded
Ford Motor, Wayne, MI	November 2003
SIFCO, Cleveland, OH	November 2003
Metaldyne, Royal Oak, MI	September 2002
Jernberg Industries, Chicago, IL	December 2001
Metlab Corporation, Wyndmoor, PA	June 2000
Utica Corporation, Utica, NY	June 2000

SIFCO, Cleveland, OH, E2M, Inc., North Potomac, MD, awarded in November 2003 (SI): SIFCO Forge Group of Cleveland, Ohio, in partnership with Energy Information Systems (EIS), E3M, the Ohio Department of Development, and the Forging Industry Association, intends to conduct a comprehensive assessment of all major energy-consuming processes and production practices (including plant equipment, waste generation, recycling, and disposal practices) at a metal forging and heat-treating plant. SIFCO will invest $105,000 and DOE will provide $100,000 toward the assessment.

Metaldyne, Royal Oak, MI, awarded in September 2002: Metaldyne and its team conducted a plant-wide energy assessment of the Hatebur forging facility that addressed opportunities to increase energy efficiency, reduce waste and pollutants, and increase productivity for the domestic steel industry. The comprehensive assessment examined all large energy-consuming equipment and systems for savings potential. The product defect inventory and the potential for defect elimination/reduction were also examined, and the manufacturing processes were examined for potential lean-manufacturing and best practices improvements. The team also identified emerging technologies that could improve manufacturing efficiency. Twenty-one assessment recommendations were identified that could improve demand- and supply-side energy management and incorporate best practices in energy management and emerging technology implementation.

Jernberg Industries, Chicago, IL, awarded in December 2001: Applied lean manufacturing principles and identified waste stream and productivity opportunities for energy-savings in its Chicago forging plant. The assessment, conducted in partnership with ComEd of Oakbrook Terrace, Illinois, and Taratec Corporation of Columbus, Ohio, focused on systems and processes that would be modified in conjunction with Jernberg's conversion from traditional batch processing to continuous processing using lean manufacturing concepts. The study identified 6 million kWh per year of electric savings and $64,000 MMBtu of natural gas savings, with a combined annual value of $791,000. Jernberg has already begun implementing the compressed air recommendations and is exploring the remaining recommendations.

Metlab Corporation, Wyndmoor, PA, awarded in June 2000 (SI): Metlab of Wyndmoor, Pennsylvania, in partnership with Energy Research Company and CSGI, Inc., conducted an assessment that included a comprehensive survey and assessment of energy use, emissions, and production practices (heat treating, surface hardening, surface coatings, tempering and annealing) in a metal heat-treating plant. As a result of the assessment, Meltlab has realized an estimated $528,400 annually in electricity cost-savings, a reduction of natural gas use by 50,070 million Btu per year, and an annual reduction of 329,400 kWh per year.

Utica Corporation, Whitesboro, NY, awarded in June 2000 (SI): The plant-wide energy assessment at Utica, in collaboration with Energy Research Company, concentrated on eight areas: utility analysis, control system, furnace analysis, air compressors, motors and drives, lighting, cogeneration, and waste treatment. The assessment resulted in six project recommendations to save electric energy and to increase productivity. Utica expects a one-time cash infusion of $720,000 from several sources, including vendor cost-sharing, a county training grant, NYSERDA funding, and DOE plant-assessment funding. Implementation of these projects could result in a 21 percent decrease in energy use and associated costs and a reduced scrap rate.

Program Support Studies

***Supporting Industries Energy and Environmental Profile*:** This study provides comprehensive descriptions of energy, environmental and economical data, manufacturing processes, and specific energy-saving opportunities for all currently addressed supporting industries.

P*rofile of Total Energy Use for U.S. Industry*: This report divides the manufacturing chain into four functionally correlated groups (raw materials, basic manufacturing, forming and finishing, and end-use industries) and provides fuel and energy-use data for each group. It reveals new supporting industries that consume large amounts of energy, such as fabricated metals, construction, computer electronics, and oil and gas exploration, yet this report does not discuss the energy-saving opportunities in these industries.

Industrial Energy Systems (IES) Energy-Saving Roadmap: This roadmap examines and analyzes all ITP industries' energy footprints and profiles and provides energy loss analyses. It identifies energy-saving opportunities (long-, mid- and short-term) applied to all industrial energy systems.

Furnace Demographic Study: This study will assess the current conditions of process heating industry energy use; types of processes used with their classification in meaningful categories; types of equipment used by different industries; number of heating equipment for different types of age; and current efficiency level for the process categories.

Industrial-Heating Equipment of the Future Conference: Industry will discuss energy-saving opportunities identified from the SI analytical studies and roadmaps, and the status of industrial-heating equipment technologies presented by industry representatives, and identify revolutionary technology options (new generation equipment/system designs and retrofits) that will result in a substantial reduction in energy intensity in various industrial processes in the near-, mid-, and long-term.

RAND ITP-Database Navigational (DBN) Tool: The DBN tool integrates research targets and needs of all ITP industry portfolios and SI, with the navigational capability to identify multiple-industry research needs and areas for further investigation. By using this tool, advanced technologies could be developed through multiple-application proposals to yield larger energy-savings and increased commercial success due to broader industry coverage. The tool is posted on the SI Web site for industry use to identify crosscutting research needs and opportunities for developing multiple-industry research proposals.

Web-Based Digitized Roadmap: Pennsylvania State University and Learning Trust, Inc., developed a Web-based digitized roadmap in FY 2003 with "Dynamic Planning" so that the PM2 can take inputs from the suppliers' chain (on market, sources of competition, product evolution, and new technologies), the other TRPs, and the results of the RAND study. This digitized version is posted on the SI Web site to attract other industries to follow suit.

Integrated Assistance for the SI Portfolio

Beyond the research funding provided by SI, many EERE technical and financial assistance resources and services are available to SI to improve energy efficiency and competitiveness in the included industries.

In addition to the nine SI technology roadmap projects (TRP), the SI portfolio supports and tracks relevant projects funded through the other IOFs. Exhibits 8 and 9 show these relationships and projects based on their respective sector.

Exhibit 8
Directly Related Project Highlights

Funding Portfolio: Steel
Advanced Control of Operations in the Blast Furnace
An Optical Sensor for Post-Combustion Control in Electric Arc Furnace Steelmaking
Development and Demonstration of a High-Efficiency, Rapid Heating, Low NOx Alternative to Conventional Heating of Steel Shapes
Development and Demonstration of Novel Low-NO_x Burners for Boilers in the Steel Industry
Dilute Oxygen Combustion System
Hot Oxygen Injection into the Blast Furnace
Improving Refractory Service Life and Recycling Refractory Materials in EAF Steel Production
Minimizing NO_x Emissions from By-Product Fuels in Steelmaking
Nitrogen Control in Electric Arc Furnace Steel Making by Direct Reduced Iron Fines Injection
Optical Sensors and Controls for Improved Basic Oxygen Furnace Operations
Optimizing of Post Combustion in Steelmaking
Development of an O_2-Enriched Furnace System for Reduced CO_2 and NO_x Emissions
Improving the Efficiency of Electric Arc Furnaces (EAF) in the United States
Temperature Measurement of Galvanneal Steel
Funding Portfolio: Chemicals
High-Efficiency, Ultra Low-Emission, Integrated Process Heater System
Ultra-Low NO_x Burners with FGR and Partial Reformer
Funding Portfolio: Petroleum
Dilute Oxygen Combustion (DOC) System
High-Efficiency, Ultra Low-Emission, Integrated Process Heater System
NO_x Emission Reduction by Oscillating Combustion
Online Sensors for Emissions Monitoring (Petroleum, Phase II)
Rotary Burner Technology Demonstration (Phase I)
Thermal Imaging Control of High-Temperature Furnaces
Very Low Emissions: Forced Internal Recirculation
Very Low Emissions: Radiation Stabilized Burner
Funding Portfolio: Combustion
Process Heat Combustion System
Super Boiler: Packed Media/Transport Membrane Boiler Development and Demonstration
Very Low Emissions: Forced Internal Recirculation (FIR) Burner
Funding Portfolio: Aluminum
Dynamic Expert System Controls for Optimal Oxy-fuel Melter Performance
High-Efficiency, High-Capacity, Low NO_x Aluminum Melting Using Oxygen-Enhanced Combustion
High-Efficiency, Low-Dross Combustion System
Innovative Energy-Efficient High-Temperature Gas-Fired Furnace
Nickel Aluminide Heat Trays and Furnace Fixtures
Rotary Burner Technology Demonstration (Phase 1)
Very Low Emissions: Forced Internal Recirculation (FIR) Burner
Funding Portfolio: Sensors and Automation
Development of a Versatile Laser Ultrasonic System and Application to Online Measurement for Process Control
Diagnostics and Control of Natural Gas Fired Furnaces via Flame Image Analysis (Glass)
Integrated Industrial Process Sensing and Control System Applied to and Demonstrated in Cupola Furnaces
Real-Time Gas Composition Analyzers for Online Process Control (Aluminum, Ceramic, Chemical, Forest Products, Glass, Metal Casting, Steel)
Thermal Imaging Control of High-Temperature Furnaces (Steel)
Tunable Diode Lasers Sensors for Monitoring and Control of Harsh Combustion Environments
Funding Portfolio: Glass
Diagnostics and Control of Natural Gas Fired Furnaces via Flame Image Analysis
Diagnostics and Modeling of High-Temperature Corrosion of Superstructure Refractories in Oxyfuel Glass Furnaces
Diode Laser Sensor for Combustion Control
Glass Furnace Combustion and Melting User Research Facility
High Luminosity, Low NO_x Burner
In-Situ, Real-Time Measurement of Melt Constituents (Sensors & Controls)

Exhibit 9
Relevant Project Highlights

Industrial-Heating Equipment
An Optical Sensor for Post-Combustion Control in Electric Arc Furnace Steelmaking
Technology of Low Coal Rate and High Productivity of Rotary Hearth Furnace Ironmaking
Pulverized Coal Injection
Quantifying the Thermal Behavior of Slags
Temperature Measurement of Galvanneal Steel
NO_x Emission Reduction by Oscillating Combustion
Innovative Vertical Floatation Melter (VFM) and Scrap Dryer
Energy Conserving Tool for Combustion-Dependent Industries
Energy Efficient Isothermal Melting Process (ITM)
Improving Energy Efficiency in Aluminum Melting
Reduction of Oxidative Melt Loss
Demonstration of a High-Temperature, Corrosion-Resistant Coating (NICE3)
Rapid Heat Treatment of Cast Aluminum Components (NICE3)
Development and Validation of a Coupled Combustion Space/Glass Bath Furnace Simulation
Waste Heat-Driven Ammonia Absorption Chiller (Combustion)
Solid-State Chemical Sensors for Monitoring Hydrogen
Sensor Fusion for Intelligent Process Control (Glass)
Online Laser Ultrasonic Measurement System
Forging
Enhancement of Aluminum Alloy Forging
Innovative Die Material and Lubrication Strategies for Forging Technology
Effects of Residuals in Carbon Steel
Removal of Residual Elements in the Steel Ladle by a Combination of Top Slag and Deep Injection
Research Related to Automated Steel Cleaning Analysis (ASCAT)
Development of the Automated Steel Cleanliness Analysis Tool (ASCAT)
Compressed Air System Optimization Project Improves Production at a Metal Forging Plant
Infrared Heating of Forging Billets and Dies Leads to Energy and Quality Improvements
A HotEye ™ Based Coordinate Measuring Machine for the Forging Industry
Utica Corporation Plant-Wide Energy Assessment Report Final Summary
Continuous Severe Plastic Deformation (CSPD) Processing of Aluminum Alloys
Materials and Process Design for High-Temperature Carburizing
Development and Demonstration of Advanced Tooling Alloys for Molds and Dies
Plastic Deformation
Welding
Hybrid Integrated Model for Gas Metal Arc Welding
Materials and Process Design for High-Temperature Carburizing
Study of Deformation Behavior of Lightweight Steel Structures Under Impact Loading
Development of Appropriate Spot Welding Practice for Transformation Hardened Steel
Development and Application of Laser-Assisted Arc Welding to Steel
Heat Treating
Integrated Heat Treatment Model for Aluminum Castings
Effects of Residuals in Carbon Steel
Controlled Thermo-Mechanical Processing of Tubes and Pipes for Enhanced Manufacturing and Performance
Removal of Residual Elements in the Steel Ladle by a Combination of Top Slag and Deep Injection
Research Related to Automated Steel Cleaning Analysis (ASCAT)
Development of the Automated Steel Cleanliness Analysis Tool (ASCAT)
Powder Metallurgy
A HotEye ™ Based Coordinate Measuring Machine for the Forging Industry
Continuous Severe Plastic Deformation (CSPD) Processing of Aluminum Alloys
Utica Corporation Plant-Wide Energy Assessment Report Final Summary
Advanced Ceramics
Development of Submerged Entry Nozzles that Resist Clogging

Advanced Ceramics (continued)
CastCon Process for Mining Applications - Michigan Technological University
Fibrous Monolithic Composites as Wear-Resistant Components for Mining Led by Advanced Ceramics Research, Inc.
Selection and Development of Metallic and Refractory Materials for Black Liquor and Biomass Gasification
Carbon Products
No relevant projects at this time.

Improving Energy Efficiency Today

BestPractices, an initiative of the U.S. DOE's ITP, works with supporting industries to identify plant-wide opportunities for energy-savings and process efficiency. Through the implementation of new technologies and systems improvements, companies across the United States are achieving immediate savings results. Involvement in BestPractices allows companies to join the ranks of forward-thinking U.S. industrial manufacturers who are saving energy and money, reducing pollution and emissions, and increasing productivity.

The Metals Processing Laboratory Users Facility (MPLUS) is a DOE-, EERE-, and ITP-user facility designated to assist research in key industries, universities, and federal laboratories in improving energy efficiency and environmental aspects, and increasing competitiveness. The goal of MPLUS is to provide access to the specialized technical expertise and equipment needed to solve metals processing issues that limit the development and implementation of emerging metals processing technologies. The scope of work can also extend to other types of materials. MPLUS enables industry and academia access to unique DOE laboratory capabilities to address key industrial materials issues. MPLUS can help SI primarily in the area of advanced ceramics. SI is fully aware of the potential opportunities that exist in the future where MPLUS can provide key research activities within the seven SI areas. MPLUS has four primary User Centers, including:

- Processing – casting, powder metallurgy, deformation processing (extrusion, forging, rolling), melting, thermomechanical processing, and high-density infrared processing
- Joining – welding, monitoring and control, solidification, brazing and bonding
- Characterization – corrosion, mechanical properties, fracture mechanics, microstructure, nondestructive examination, computer-controlled dilatometry and emissivity
- Materials/Process Modeling – mathematical design and analyses, high-performance computing, process modeling, solidification and deformation, microstructure evolution, thermodynamic and kinetic and materials database

Disseminating Research Results

The SI initiative performs various outreach activities to disseminate R&D results and enable industry to implement energy-saving practices and technologies. This includes participating in conferences and maintaining an up-to-date Web site that highlights SI activities. In addition, SI sponsored the pilot project *"Translating Paper-Based Roadmaps to Digital Form"* for the PM2 industry. Pennsylvania State University (PSU) developed a Web site that offers users a digital version of the PM2 roadmap that can be updated via user comments to individual elements on the Web site. The information on the Web site is used to develop and modify respective technology roadmaps with expert input. This Web site organizes information about the roadmapping process and provides resources for professionals.

Energy Analysis – Targeting Energy Savings for Supporting Industries

Targeted national energy-savings for the supporting industries, by the year 2020 (and 2010), are as follows:

Industrial-Heating Equipment: The U.S. industrial-heating equipment industry consumes approximately 5.20 quad per year of energy. Industrial-heating equipment (heating and heat recovery devices) supply heat to nearly all manufacturing processes and consume nearly 17 percent of the total U.S. industrial energy. The nine generic industrial applications of industrial heating equipment (IHE) are: fluid heating, calcining, drying, heat treating, metal heating, melting, smelting, curing and forming, and "other heating." Over the past 20 years, process heating improvements have made significant contributions to the environment as a

result of reducing combustion-related emissions. Nevertheless, the overall thermal efficiency of IHE is still below practical limits. Currently, the process-heating efficiency varies between 15 and 80 percent. Using advanced technologies and operating practices in the production of materials such as steel, cement, composites, etc., or value-added products such as electronics, computer chips, cosmetics, and textiles can reduce industrial-heating equipment energy consumption by an additional 5 to 25 percent. Assuming 75 percent of the processes will experience a 5 percent savings, and 25 percent of the processes will experience a 25 percent savings, the total improvements will translate to an energy-savings potential of about 550 trillion Btu per year in the U.S.

Heat Treating Industry: The U.S. heat treating industry consumes approximately 0.50 quad per year (in 55,000 furnaces located at 5000- 6000 facilities). This industry uses nine major processes to achieve specific material structures, chemical compositions, and physical properties, i.e., annealing, austenitizing, nitriding, carbonitriding, carburizing, normalizing, quenching, stress relieving and tempering. It is closely linked to the manufacture of products and parts made of steel, alloys of aluminum, copper, magnesium, nickel and titanium, and vital to parts that are essential to automotive, aircraft, spacecraft, oil, steel, heavy equipment, consumer products, mining, farming, and defense industries. The major performance targets for this industry include: energy consumption reduced by 80 percent; predictable distortion; and process times reduced by 50 percent. Based on average energy savings, assumed 25 percent for electric furnaces (currently operating at 80 -85 percent efficiency) and 40 percent for fuel-fired furnaces (operating from 40 percent to 80 percent), the potential energy savings for this area is about 144 trillion Btu per year.

Forging Industry: The U.S. forging industry consumes approximately 28-37 trillion Btu/year of energy. It supplies high-strength, high-quality components to major U.S. industries such as automotive and truck, agricultural machinery, general industrial equipment, aerospace, off-highway equipment/railroad, ordnance/ shipbuilding, and others. Forged components are in over 20 percent of the products that comprise the GDP of the United States. The major performance targets for this industry include: forging process energy reduced by 20 percent; work rejection rate reduced to 25 parts per million; material consumption reduced by 15 percent; scrap rate reduced by 90 percent; die-life increased 10 times; and aerosols and harmful combustion gases eliminated. Based on 60 percent to 80 percent improvement in energy efficiency due to replacement of fuel with induction heating, and avoidance of continuous heating, the potential energy savings for this area is about 8 trillion Btu per year.

Welding Industry: The U.S. welding industry consumes approximately 0.13 quad per year of energy. The welding techniques include fusion, solid-state, weld bonding, diffusion, brazing and soldering. End-users for this industry include heavy and light automotive, aircraft, aerospace, and petroleum/energy industries which use more than 100 processes involving metal-welding, polymers, ceramics and new composites. The major performance targets for this industry include: energy consumption reduced by 50 percent; increasing industry use of welding by 25 percent; and new welding technologies and materials developed to permit fabrication methods available for all engineering applications. Based on 40 percent savings due to decreased preheating and post heating, lower heat input process, and avoided over-welding, the potential energy savings in this area is 52 trillion Btu per year.

Powder Metallurgy and Particulate Materials (PM2) Industry: The U.S. PM2 industry produces near-net shape components with tight dimensional tolerances, at modest temperatures, thus minimizing finishing operations, cost, and energy use. The energy consumption for finished parts is reduced to 29 MJ/Kg, compared to 38 for casting, 41 for extrusion, 49 for hot forging, and 82 for machining. This industry makes components that are: (a) difficult to make by other methods (e.g., tungsten, molybdenum, porous bearings, filters, soft magnetic); (b) cost-effective alternatives for automotive, metal cutting, hand tools, industrial motors, business machines, aircraft turbine engines, surgical instruments, drilling equipment applications; and (c) complex with special properties required for pharmaceutical, electronics and consumer product applications. The major performance targets for this industry include: enhanced material properties and performance; improved manufacturing and processing; and improved enabling technologies and infrastructure. The energy-saving potential for this area will be known after the bandwidth study for this area is complete.

TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

The SI initiative offers a wide array of tools and publications to help supporting industries improve their productivity and energy efficiency. These resources are available on-line at the SI Web site at http://www.oit.doe.gov/related.

BestPractices Tools

ITP's BestPractices team works with the industry to identify plant-wide opportunities for energy-savings and process efficiency. Through implementation of new technologies and systems improvements, companies across the United States are achieving immediate savings results. Opportunities for serving these benefits to supporting industries are important because of the various plants involved. Both ITP's BestPractices and the SI initiatives work with the supporting industries to identify opportunities to use energy more efficiently through new technology implementation, plant assessments, and system improvements. SI supports the deployment of software tools that assist industry in saving energy. These powerful tools help industry identify and analyze energy-savings opportunities in the plant. The following BestPractices tools help supporting industries realize energy-savings:

Process Heating Assessment and Survey Tool (PHAST) - Process Heating Assessment and Survey Tool (PHAST) provides an introduction to process heating methods and tools to improve thermal efficiency of heating equipment. The tool surveys process-heating equipment that uses fuel, steam, or electricity, and identifies the most energy-intensive equipment. Industry can also perform an energy (heat) balance on selected equipment (furnaces) to identify and reduce non-productive energy use, and compare performance of the furnace under various operating conditions to test "what-if" scenarios. Software for the PHAST tool can be downloaded at http://www.oit.doe.gov/bestpractices/process_heat.

Steam System Assessment Tool - The Steam System Assessment Tool (SSAT) allows users to assess potential savings from individualized steam-system improvements. Users input data about their plant's conditions, and the SSAT generates results detailing the energy, cost, and emissions savings that various improvements could achieve. Software can be downloaded at http://www.oit.doe.gov/bestpractices/steam/tools.shtml

Steam System Scoping Tool - The Steam Scoping Tool guides an evaluation of a how a company manages a steam system against well-documented industry best practices. The MS Excel spreadsheet allows the user to respond to questions regarding operation and maintenance practices. The spreadsheet calculates a rating score to indicate how the user's system compares to a high industry standard. Software can be downloaded at http://www.oit.doe.gov/bestpractices/steam/tools.shtml.

NO_x Scoping Tool - The NOx scoping tool is designed to assist the development of a cost-effective, plant-wide strategy and plan for NOx reduction and energy efficiency improvements. This tool takes inventory of NOx sources, methods of NOx reduction, and information on commonly used methods of energy efficiency improvements and NOx reduction.

Publications

Industrial-Heating Equipment

- *Check Burner Air to Fuel Ratios*
- *Preheated Combustion Air*
- *Process Heating Roadmap to Help U.S. Industries Be Competitive*
- *The Big Picture on Process Heating*
- *Seven Ways to Optimize Your Process Heat System*
- *Indirect-Fired Kiln Conserves Scrap Aluminum and Cuts Costs*
- *Metal and Glass Manufacturers Reduce Costs by Increasing Energy Efficiency in Process Heating Systems*
- *Roadmap for Process Heating Technology: Priority Research and Development Goals and Near-Term Non-Research Goals to Improve Industrial Process Heating*

Heat Treating

- *Research & Development Plan to Achieve Vision 2020*

- *Heat Treating Industry Vision 2020*
- Report of the *Heat Treating Technology Roadmap Workshop*, April 1997

Welding

- *Vision for the Welding Industry*
- *Welding Technology Roadmap*

Advanced Ceramics

- *Advanced Ceramics Technology Roadmap*
- *Applications for Advanced Ceramics in Aluminum Production: Needs and Opportunities*, February 2001
- *Advanced Ceramics in Glass Production: Needs and Opportunities*, January 1999
- *Opportunities for Advanced Ceramics to Meet the Needs of Industries of the Future*, June 1998

Forging

- *Forging Industry Technology Roadmap*, November 1997
- *Forging Industry Vision of the Future*, November 1996
- *Ohio State University Program*

Powder Metallurgy and Particulate Materials (PM2)

- *Powder Metallurgy and Particulate Materials Industry Vision and Technology Roadmap*

Carbon Products

- *The Carbon Products Industry Vision for the Future: A World of Carbon Products*, September 1998

Fact Sheets

The SI initiative disseminates information on current and past projects through project fact sheets. The information provided in each fact sheet includes the objective, accomplishments, benefits, principlal investigator, and project partners. All SI fact sheets are available on-line at http://www.oit.doe.gov/related/port_sitrp.shtml.

HOW TO GET INVOLVED AND CONTACT INFORMATION

Partnership Information

Public-private partnerships are the foundation of ITP's technology delivery strategy. ITP includes its partners in every phase of the technology development process to focus scarce resources where they can have the greatest impact on industrial energy efficiency. To learn more, please visit our Web site at http://www.eere.energy.gov/industry.

- Collaborative, cost-shared research and development projects are a central part of ITP's strategy. Annual solicitations provide technology development opportunities in a variety of energy-intensive industries.

- Industries of the Future Partnerships increase energy efficiency in the most energy-intensive industries. In addition to cost-shared research and development projects, industry partners participate in the development of vision and roadmap documents that define long-term goals, technology challenges, and research priorities.

- Allied Partnerships provide an opportunity for ITP to reach a broad audience of potential customers by allying with corporations, trade associations, equipment manufacturers, utilities, and other stakeholders to distribute industrial energy efficiency products and services. By becoming an Allied Partner, an organization can increase its value to clients by helping them achieve plant efficiencies.

- State energy organizations work with ITP in applying technology to assist their local industries. ITP assists states in developing partnerships to mobilize local industries and other stakeholders to improve energy efficiency through best practices, energy assessments, and collaborative research and development.

- EERE's technical programs (of which ITP is one of 11) give manufacturers access to a diverse portfolio of energy efficiency and renewable energy technologies and bring advanced manufacturing technology to the renewable energy community. For more information, access the EERE home page at http://www.eere.energy.gov.

- The President's Climate VISION (Voluntary Innovative Sector Initiatives: Opportunities Now) effort also offers opportunities for manufacturers to pursue cost-effective actions that will reduce greenhouse gas emissions. See http://www.climatevision.gov for details.

Access to Resources and Expertise

The Industrial Technologies Program provides manufacturers with a wide variety of industrial energy efficiency resources to help your company cut energy use right away. Visit our site at http://www.eere.energy.gov/ industry or call the EERE Information Center at 877-337-3463 to access these resources and for more information.

- ITP offers energy management best practices to improve energy efficiency throughout plant operations. Improvements to industrial systems such as compressed air, motors, process heat, and steam can yield enormous savings with little or no capital investment.

- Our suite of powerful system optimization software tools can help plants identify and analyze energy-saving opportunities in a variety of systems.

- Training sessions are held several times per year at sites across the country for companies interested in implementing energy-saving projects in their facilities. DOE software tools are used as part of the training sessions.

- ITP's qualified industrial energy specialists will work with your plant personnel to identify savings opportunities and train staff in the use of ITP software tools.

- Our extensive library of publications gives companies the resources they need to achieve immediate energy savings.

- Plant-wide energy assessments are available to manufacturers of all sizes interested in cutting their energy use. Cost-shared solicitations are available each year for plant-wide energy assessments. In addition, no-cost, targeted assessments are provided to eligible facilities by teams of engineering faculty and students from 26 university-based Industrial Assessment Centers around the country.

- The DOE Regional Offices provide a nation-wide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in the Southeast, Northeast, Midwest, Central, Mid-Atlantic, and Western regions. Visit http://www.eere.energy.gov/rso.html for more information.

Where to Go For More Information

Visit our Web site: http://www.oit.doe.gov/related/

Learn about all EERE programs: http://www.eere.energy.gov

EERE Information Center answers questions on EERE's products, services and 11 technology programs, refers callers to the most appropriate EERE resources, and refers qualified callers to the appropriate expert networks. You may contact the EERE Information Center by calling 1-877-EERE-INF (1-877-337-3463) or by completing the form at this site: http://www.eere.energy.gov/informationcenter. A customer service specialist or energy expert at the EERE Information Center will respond to your inquiry.

For print copies of DOE, EERE and ITP Publications, contact the
Energy Efficiency and Renewable Energy Information Center
P.O. Box 43165
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http://www.eere.energy.gov/informationcenter/

For questions regarding Supporting Industries activities, please contact:
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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and great energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as a vital new "energy carrier"

The Opportunities

Biomass Program
Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program
Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program
A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program
Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program
Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program
Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program
Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program
Utilizing the sun's natural energy to generate electricity and provide water and space heating

Weatherization & Intergovernmental Program
Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and business

Wind & Hydropower Technologies Program
Harnessing America's abundant natural resources for clean power generation

To learn more, visit www.eere.energy.gov

Supporting Industries – Industry of the Future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry

U.S. Department of Energy
Energy Efficiency and Renewable Energy

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